CLOSURE WITH FRANGIBLE TAMPER-EVIDENT BAND

FIELD OF THE INVENTION

The present invention relates to closures for containers, and more particularly to tamper-evident closures for containers.

BACKGROUND TO THE INVENTION

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

There exists extensive prior art in relation to the design and manufacture of tamper-evident closures for containers, such as for example US Patents Nos. 4,653,657 (Papavasilopolous), 4,807,771 (Roy), 5,660,288 (Nyman), 6,551,093 (Taha) and 6,640,988 (Taha) the disclosures of which are hereby incorporated into this specification by way of cross-reference.

One problem that exists with prior art tamper-evident closures is the loss of sealing between the closure and container opening prior to the tamper-evidence features operating.

A further problem is the poor visibility of the status of the tamper-evident features, with the consequence that a consumer may not discern that the seal of the container has been broken.

Tamper-evident band design on most closures includes an interference between the container neck and the tamper band. Often upon opening and removal of the closure the tamper-evident band does not drop away from the closure body but remains by means of interference between the tamper-evidence band and the container neck held on the neck in a similar position to the tamper band on an un-opened package or in the case of malicious tampering a container may be opened and contaminants introduced and the closure replaced and the tamper-evidence band pushed back into close proximity to the closure to give the appearance of an un-opened package.

It is an object of the present invention to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

SUMMARY OF THE INVENTION

One aspect of the present invention deals especially with the need for a proper relationship between sealing means and tamper-evidence means such that the tamper-evidence means operates prior to the seal being breached. This avoids the possibility apparent with many so-called tamper-evident closures whereby by malicious tampering or inappropriate application torque and/or relaxation of the closure causing the seal between closure and container neck to be breached without the tamper-evidence means operating and allowing the contents to be degraded by action of atmosphere or the malicious introduction of contaminants.

A further aspect of the present invention provides a tamper-evident closure for a container with tamper-evident means and means of dispensing one or more additives into the container and a tamper-proof cover to protect additive dispensing means.

A further aspect of the present invention provides a tamper-evident closure for a container with tamper-evident means and a dispensing means for dispensing the contents of the container in a controlled or limited manner, and a re-usable tamper proof cover for said dispensing means.

BRIEF DESCRIPTION OF DRAWINGS

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 depicts the dispensing end of a container, with the neck of the container adapted to include tamper-evident features according to one aspect of the present invention;

Fig. 2 depicts the dispensing end of the container illustrated in Fig. 1, with an alternative embodiment of the tamper-evident features on the neck of the container;

Fig. 3 is a cross-sectional elevation of a tamper-evident closure according to a preferred embodiment of the present invention;

Fig. 4 is a cross-sectional elevation of a tamper-evident closure located on the neck of a container;

Fig. 5 is an enlarged view of a projection located on the neck of the container illustrated in Fig. 1;

Fig. 6 is a cross-sectional plan view of the neck of the container illustrated in Fig. 1, taken in the plane W-W;

Fig. 7 is an enlarged view of a preferred embodiment of a tamper-evident band according to an aspect of the present invention;

Fig. 7a is a view of the mould assembly apparatus for forming the tamper-evident closure illustrated in Fig. 2;

Fig. 7b is an enlarged view of the mould assembly apparatus shown in Fig. 7a illustrating the formation of the lower section of the skirt and tamper-evident band of the closure;

Fig. 8 is a cross-sectional elevation of a tamper-evident closure located on the neck of a container according to a further aspect of the present invention;

Fig. 9 is a cross-sectional elevation of a tamper-evident closure according to a further aspect of the present invention and including a dispensing arrangement for dispensing an additive to the contents of the container;

Fig. 10 is a further embodiment of the tamper-evident closure depicted in Fig. 9;

Fig. 11 is a further embodiment of the tamper-evident closure depicted in Fig. 9;

Fig. 12 is a cross-sectional elevation of a tamper-evident dispensing closure according to a further aspect of the present invention, illustrated in position on the neck of a container;

Fig. 13 is a cross-sectional elevation of a further embodiment of the tamper-evident dispensing closure illustrated in Fig. 12 further including a tamper-evident cover;

Fig. 14 is a plan view of the tamper-evident dispensing closure shown in Fig. 12;

Fig. 15 is a cross-sectional elevation of a further embodiment of a dispensing portion of a dispensing closure and cover;

Fig. 16 is a view of the mould assembly apparatus for forming the closure illustrated in Fig. 12;

Fig. 17 is a cross-sectional elevation of a further embodiment of tamper-evident closure and cover;

Fig. 18 is a cross-sectional elevation of an orifice device and associated cover for fitting to the dispensing orifice of a container closure.

Figs. 19 to 24 illustrate a prior art tamper-evident closure;

Fig. 25 illustrates a further embodiment of tamper-evident closure according to a further aspect of the present invention;

Fig. 26 illustrates a prior art tamper-evident closure;

Figs. 27 to 33 illustrate a further embodiment of tamper-evident closure, and apparatus for making same, according to a further aspect of the present invention;

Figs. 34 to 36 illustrate a further embodiment of a container closure incorporating various aspects of the present invention; and

Figs 37, 38 and 38a illustrate a further embodiment of the tamper-evident closure, incorporating a receptacle or cup to enable items to be contained within the closure receptacle.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1 illustrates a neck portion 10 of a container. Typically the container is an injection blow-moulded container formed from a suitable material such as polyethylene terephthalate (PET). However, it should be noted that the invention applies to various forms of containers made from various materials. The neck 10 includes a helically threaded section 12 formed on the external surface 14 of the neck 10. Typically, the threaded section 12 is integrally formed on the neck 10. The threaded section 12 is threads are adapted to engage with a complementary helically threaded section on the internal face of the skirt of a tamper-evident closure.

The neck 10 includes an annular tamper-evident bead 16 located below the threaded section and extending radially outward from the external surface of the neck 10. The tamper-evident bead 16 is preferably moulded on the external surface of the neck 10. Extending downwardly from the bead 16 are one or more discretely spaced projections 18 located around the circumference of the neck 10. In one example, the container neck 10 is provided with four substantially equally spaced projections 18. The projections 18 are adapted to engage with tabs on a tamper-evident band of a closure and facilitate the breaking the band from the skirt of the closure.

Fig. 3 is a cross-section of a tamper-evident closure 100 adapted to fit to the container neck portion 10 illustrated in Fig. 1. The closure 100 is depicted prior to its application to a container 10. Typically, the closure is a one-piece moulded construction. The closure 100 includes a top wall 102 and downwardly extending

skirt 104. The closure includes a helically threaded section 106 located on the internal face 108 of the skirt which is adapted to engage with the corresponding helically threaded section 12 on the external surface of the neck 10 of the container. The closure further includes a tamper-evident band 110 which extends downwardly from the skirt of the closure. The tamper-evident band is connected to a lower surface 112 of the skirt 104 by a frangible section 114 formed by a series of circumferentially spaced ribs 116 separated by slots 118. The ribs 116 are of a cross-section which provides sufficient strength to withstand typical forces which may be imparted during handling and/or the application of the closure to the container neck. The tamper-evident band includes an annular wall 120 from which extends a series of discretely spaced tabs 122. The tabs 122 are connected to the lower surface of the annular wall 120 by means of a hinged section 124. Initially, the tabs 122 extend radially inwardly at an obtuse angle with respect to the annular wall 120 to facilitate removal from the mould. Subsequent to the moulding of the closure, the tabs 122 are moved to a perpendicular or acute angle with respect to the annular wall 120. Each tab 122 includes an engagement face 124 adapted to engage with a projection 18 on the neck 10 of the container during removal of the closure from the container.

Extending downwardly from the inner surface of the top wall 102 of the closure is an annular sealing member 130. The sealing member 130 includes a circumferentially extending apex 132 adapted to seat against the inner wall of the neck portion of the container and provide sealing of the container. Extending inwardly from the wall 108 and downwardly from the top 102 is secondary sealing member 134 which engages outer surface 14 and/or the upper surface 15 of neck 10.

The design of the projections 18 will now be described in further detail. Fig. 5 is a cross-section taken in the plane Y-Y of Fig. 1 between Z-Z', illustrating the profile of a projection 18, whilst Fig. 6 is a cross-section of the neck portion taken in the plane W-W of Fig. 1 illustrating a preferred location of the projections 18 around the outer periphery of the neck. To remove the closure from the neck of the container the closure is rotated in an anti-clockwise direction as indicated by the arrow X in Fig. 6.

Referring to Figs. 5 and 6, the projections 18 are moulded on the external surface of the neck below the tamper-evident bead 16. Each projection comprises a series of faces, 18a, 18b and 18c. Face 18a is of a dimension J which is equal to or

less than the distance that the tamper bead 16 projects beyond the external surface of the container neck. Face 18a is designed to interact with tabs 122 on closure 100 such that upon rotation of the closure, the engagement face 124 of tab 122 engages with the angled engagement face 18a. Upon further rotation of the closure, the tab 120 is driven downwardly along the angled face 18a, thereby placing stress on the frangible ribs 116 and facilitating the severance of the frangible ribs 116, thus promoting early tamper-evidence operation by opening a discernable gap between the lower edge of the skirt 104 and the tamper-evident band 110.

Fig. 2 depicts an alternative embodiment wherein the face 18a includes a portion 18a' of varying angle with respect to the plane of the lower surface of the tamper-evident bead 16. In one embodiment the face has an initial curved section which provides a gently increasing angle with respect to the lower surface of the bead. This acts to gradually and progressively stretch and weaken the frangible ribs 116 so that when the engagement face 124 of a tab 122 on the tamper-evident band 110 reach the more steeply angled section of the face 18a, the frangible ribs 116 are already sufficiently weakened and further rotation of the closure urges engagement face 124 below face 18m, thereby promoting breakage of the frangible ribs. In an alternative embodiment (not depicted), the face 18a may comprise two or more discrete planar surfaces of progressively increasing angle with respect to the tamper-evident bead 16. In this embodiment, the face 18a has an initial surface angled with respect to the plane of the lower surface of the tamper-evident bead 16, followed by one or more further surfaces of increasing angle with respect to the plane of the lower surface of the tamper-evident bead 16.

Fig. 4 shows sealing means in sealing engagement with the external wall of container neck 10.

According to a further aspect of the invention, the distance between the underside face of container tamper-evident bead 16 and the projection face 18m and the extent and location of the progressively ramped portion 18a' of projection face 18a are designed to take into account:

(i) the distance representing clearance between tamper-evident band 110 engagement surfaces 124 and the underside of tamper bead 16 when the closure is fully applied to the container . That is to take account of the

relative position of engagement surfaces 124 and progressively ramped portion 18a' of projection face 18a so that said engagement surfaces 124 make contact with said progressively ramped portion 18a' before contacting the more steeply angled section of projection face 18a; and

(ii) the distance over which the frangible ribs 116 deform in an axial direction before breaking.

It should also be noted that for a particular container it is possible to determine in advance the relative location of any portion of the closure tamper-evident band 110 to projections 18 when the closure is fully applied to the container.

It is possible to reduce the force necessary to initially stretch and break the first frangible ribs by selectively designing one or more of the frangible ribs 116 be weakened. It is possible to predetermine which ribs will be first to advance to projections 18 upon removal of the closure and therefore the weakened frangible ribs can be located as to be first to be stretched by the downwards urging along projection face 18a.

Face 18b is of a dimension K which at least exceeds the width of the space 122c between the engagement portions 122 of the tamper-evident band 110 so that the free ends 126 of the tabs 122 will be retained below the edge 18m of the projection 18, thereby making a more visible gap between the severed tamper-evident band 110 and the closure skirt 104.

Face 18c has a ramped surface so as to minimise interference and enable the tabs 122 to pass easily over the projections upon the initial application of the closure to the neck of the container. It should be noted that the closure can be designed to be applied by axial movement (for example by using a multiple thread) rather than by rotation.

Fig. 7 is a partial perspective cross-sectional view of a preferred embodiment of the tamper-evident band 110 prior to application to a container. The tamper-evident band 110 depends from the lower face of the skirt of the closure (not depicted) by means of a series of ribs 116 which form a frangible section. The band includes an annular wall 120 and a plurality of circumferentially spaced tabs 122 connected to an inner surface of the annular wall. The tabs 122 extend from the lower surface of the annular wall 118 by means of a hinged section 124. The tabs 122 terminate at a free

end which includes an engagement face 124. Initially the tabs 122 extend radially inwardly at an obtuse angle with respect to the annular wall 120 and then are subsequently bent inwardly along the hinge line 124.

In one embodiment (not shown), the engagement surfaces 124 of the tabs 122 have an angle corresponding to the angled faces 18a of the projections 18 so that engagement surfaces 124 tend to make contact with faces 18a over a greater portion of the engagement surface 124. This tends to avoid the curling or folding of the junction of surface 124 and 124a thereby assisting in directing engagement surface 124a downwards along angled faces 18a.

Preferably, one or more perforations 128 are provided along the hinge line 124 to allow for drainage of product spilled during the filling process.

Recesses 122a of width R and depth S are provided between each tab 122. The depth 'S' is preferably such that during application of the closure to the container the hoop strength existing in the continuous annular portion of the band along line extending from the bases 122e of recess 122a is sufficiently reduced to enable flexing along the line of the bases 122e of the recess 122a to facilitate a more easy application of the closure to the container.

The depth 'S' of the recess 122a is preferably greater than the distance between dotted lines W and X of Fig. 1 thereby allowing the free end 124 of tabs 122, at least when adjacent to angled engagement faces 18a, to remain in close proximity to the container neck and allow the free end of closure engagement surfaces 124a to engage angled engagement faces 18a. As removal rotation continues the free end of engagement surfaces 124a are driven downwards along angled engagement faces 18a thereby inducing axial stress in the frangible ribs 116 resulting in breakage of one or more of the ribs and promoting early separation of the tamper-evident band 110 from closure 100. The continuous annular portion of the engagement portions 122 of the tamper-evident band 110 along the line extending from the bases 122e of recess 122a enhances the effectiveness of contact between said engagement surfaces 124a and said angled engagement faces 18a by assisting to maintain the location of engagement surface 124a.

When applying the closure to a container the ramped upper shoulder of the tamper-evident bead 16 urges the tamper-evident bead engagement portion 122 of the

tamper-evident band 110 against the inside wall of the tamper-evident band so that the tamper-evident band 110 may pass over the tamper-evident bead 16 and the ramped surfaces 18c of projections 18 urge the free edges of the upper regions of engagement portions 122 against the inside wall of said tamper-evident band 110 so that the said engagement portions of the tamper-evident band 110 may pass over the projections 18.

In another example of closure tamper-evident band at least four of the recesses 122a referred to as location recesses may have dimension 'R' increased in size and located so that upon full application to the container neck the center point of each said location recess is approximately adjacent the center of each of the similar number (being four in this example) of projections 18 such that the engagement surfaces 124 have clearance from either side of at least faces 18b of projections 18. In the same example at least four other recesses 122a are smaller in 'R' dimension than the said location recesses and ideally smaller in 'R' dimension than the length of that portion of lower face 18m which adjoins face 18b of projections 18. Upon removal rotation engagement surfaces 124 contact the said projections 18 and are urged downwards along faces 18a thereby placing axial stress sequentially on and substantially or completely severing at least the majority of frangible ribs 116 and moving the tamper-evident band 110 below the lower surface 18m of projections 18. Recesses 122a other than the location recesses being of less in dimension 'R' will pass under those portions of lower face 18m which adjoins face 18b of projections 18 thus continuing the sequential axial stressing and substantial severing of frangible ribs 116 and separation of the tamper-evident band 110 from closure 100 thus promoting early and more visible contemporaneous evidence of opening.

Referring to Fig. 28, a partial cross-section of the neck portion of a container and closure is depicted. The neck portion of the container includes a tamper bead 16 which has a lower surface which lies in one plane. In accordance with a further aspect of the invention, the closure is designed according to the following formula (formula A):

$$A \geq B + C + D + E + F$$

wherein:

(i) A is the distance over which the sealing member can seal against the inner wall or outer wall (example not shown) of the neck portion of the container;

(ii) B is the distance between the engagement surface 61 of the tamper-evident bead 16 and the engagement surface 124 of the tabs 122 when the closure is fully applied to the container;

(iii) C is the amount of compression that occurs in the said tamper-evident band tabs 122 during the process of removal of the closure;

(iv) D is the amount of stretch that occurs under stress during closure removal in the skirt and the frangible ribs 116 connecting the tamper-evident band 110 to the closure skirt 104;

(v) E is the distance equal to the tolerance allowed in the measurement specifications of the container neck 10 and the closure 100; and

(vi) F is the distance required for a margin of safety for a particular closure and neck combination so as to promote the operation of the tamper-evidence means prior to loss of the seal between closure and container neck.

In a variant of the above formula (formula A) the dimensional units are measured in degrees of removal rotation of the closure. This alternative formula is useful in tamper-evident closure systems which use projections 18 of the type illustrated in Figs. 1 and 2.

The various aspects of the closure invention described above may be designed to be manufactured using the mould equipment and method as disclosed in US Patent Nos. 6,551,093 and 6,640,988 (Taha) the disclosures of which are hereby incorporated in this specification. In one modification, illustrated in Fig. 7, the engagement portion of the tamper-evident band 110 may be moulded in a position such that the angle 'A' between line A1 extending from and parallel to the inside wall of the tamper band 110 and line A2 extending from and parallel to the outside wall of the annular engagement portion 122 of the tamper-evident band is greater than 0° and less than 45°, and preferably approximately 30°.

Fig. 6 is a cross-section of the container neck 10 showing the preferred location of ramped projections 18 below tamper bead 16 (represented by the annular

broken line). A method of manufacture and mould assembly to form the container neck is as follows.

The line V-V is the parting line of two mould portions. As shown by the line V1-V1 in Fig. 1, the mould part line may advantageously follow the path dictated by the boundary between faces 18a and 18b, or 18b and 18c, so that at least the ramped faces 18a in the projections 18-2 and 18-4 may be formed in the mould portions Q_3, Q_1 respectively.

The angle between the leading edge of the projections and the wall of the neck, shown as "F" in Fig. 6, is preferably 90° or less.

In a two-piece mould and taking a section through the part of the container mould forming the neck and projections 18 with the parting line being the straight line from 90° to 270° (3 o'clock to 9 o'clock) 0° being at 12 o'clock then the section is nominally divided into four equal quadrants, with quadrants Q_1 and Q_2 both being in the mould first half and quadrants Q_3 and Q_4 being in the mould second half, wherein Q_1 lies between 270° and 360°, Q_2 lies between 0° to 90°, Q_3 lies between 90° to 180°, and Q_4 lies between 180° to 270°.

Only in quadrants Q_1 and Q_3, or at the juncture between them and quadrants Q_2 and Q_4, may faces 18a be formed with an angle 'F' of 90° or less.

Projections 18 moulded with face 18a formed in quadrant Q_1 from 270 to about 359° (the difference between 359 and 360° representing an allowance for "draw" to enable the mould to open without interference with at least the faces 18a) may have faces with angle 'F' decreasing from 90° by 1° for every degree less than 359°, and similarly in quadrant Q_3 from 179°.

Having angle 'F' less than 90° is advantageous in that the free edges 124, 124a of engagement portions 122 upon removal rotation of the closure and contact with faces 18a will tend to be urged inwards across faces 18a towards the neck wall 14 and thereby to remain in close proximity to faces 18a and the container neck wall 14 tending to ensure continued movement downwards along face 18a.

However if projections 18 are moulded with at least the surface of faces 18a formed by the mould in quadrants Q_2 and Q_4 (other than at the juncture with quadrants 1 and 3) faces 18a will have angles 'F' greater than 90° which will upon removal rotation of the closure have the undesirable effect of tending to direct the free edges

124, 124a of engagement portions 122 away from container wall 14 and past projection 18.

It should be noted that the mould parting line may deviate (from a centreline where one mould half is a mirror of the other) to accommodate the forming of one or two of projections 18 thus one half of the mould may project across the "mirror image parting line" into the space normally occupied by the second mould half and the said second mould half will have a corresponding shape to accommodate the projecting first half.

In removal operation of most commonly used single thread closures from a container approximately at least the first 90° of removal rotation does not lift the closure in the direction of removal because there is firstly an amount of dimensional tolerance difference between the cooperating threads on container and closure.

One example of the present invention container neck preferably has four of projections 18 located equidistant, or substantially equidistant, so that within approximately the first 90 to 120° of closure removal rotation most of the free ends 124 and 124a of engagement portions contact the said projections and are urged downwards along faces 18a thereby placing axial stress on and substantially or completely severing the majority frangible bridges and moving the tamper band 110 below the lower surface 18m of projection 18 providing an early and more visible tamper-evidence.

Another example of the present invention container neck preferably has two or more of projections 18 located in quadrants Q_1 and Q_3 such that all projections 18 have an angle 'F' less than 90° or substantially equidistant so that within approximately the first 90° of closure removal rotation most of the free ends 124 and 124a of engagement portions contact the said projections and are urged downwards along faces 18a thereby severing the majority frangible bridges and moving the tamper band 110 below the lower surface 18m of projection 18 providing an early and more visible tamper-evidence.

The parting line V1-V1 in Fig. 1 may vary from that shown and still achieve the forming of the said ramped projections.

The container mould may also be of the expanding cavity type with more than two segments which will allow moulding of at least one of projections 18 in each segment of an expanding cavity mould.

The moulding of the closure 100 depicted in Fig. 4 will now be described with reference to Fig. 7a. The sequence of moulding steps is as follows. Depending upon the profile of the bore seal 130, core 4 moves in the direction of the arrow in order to release the inside bore seal 130. However, it should be noted that depending upon the profile of the bore seal 130 such movement of core 4 may not be necessary. The outer core sleeve moves also in the same direction in order to release the outside of the tamper-evident band 110.

Stripper ring 22, ejector sleeve 5 and inner core 6 move in the opposite direction. At the end of this motion, closure 100 has been stripped of the threaded core 3, bore seal 130 has also been totally freed from the threaded core 3. The inner barrel 42 is also clear of front face of core 4. At this point, inner core 6 and stripper 21 are arrested. The ejector sleeve 5 is then pushed further forward resulting in inner barrel 42 being pushed off inner core 6 and outside of the tamper-evident ring 110 being pushed outside of stripper ring 22. The undercut 44 is free to pass over inner core 6 as core 4 is completely disengaged from inner barrel 42.

Figs. 8 to 11 illustrate a further aspect of the present invention. This aspect provides a container closure, preferably having tamper-evidence means, with a dispensing means to dispense into a container connected to the closure one or more additives contained within the dispensing means. The advantages of such a dispensing device include the ability to keep additives separate from both of the atmosphere and contents of the container until the time of use by the consumer.

Fig. 8 depicts a closure 100 having a top wall 20 with a circular opening 22 of diameter "P" formed therein. One or more annular ribs 24 are provided on the peripheral surface of the opening 22.

The closure 100 includes a depending skirt 30 having helical threads 32 adapted to cooperate with corresponding helical threads 66 on the external surface of the container neck 60 to apply and remove the closure to and from container neck.

Fig. 9 illustrates the closure 100 of Fig. 8 with a plunger housing 200 fitted in the opening 22 of the top wall 20. It is to be noted that whilst in the embodiment

depicted the plunger housing 200 is illustrated as a separate component, it may be integrally formed as part of the closure 100. In the embodiment depicted, the plunger housing 200 includes a pair of radially extending flanges 210, 212 which act to locate and retain the housing 200 within the opening in the top wall 20 of the closure. The housing 200 is pressed into position, in the top wall 20, with the lower flange 210 including an angled face 214 to facilitate insertion of the plunger housing into the opening 22. The upper flange 212 may be of greater diameter than the lower flange 210.

Located between the radial flanges 210, 212 the plunger housing 200 has an outer wall 220 of diameter "R" which is in sealing engagement with the annular ribs 24 located in the opening of the top wall 20.

The plunger housing 200 has an inner wall 230 which defines a bore 232 for receiving plunger 240. The bore 232 includes a pair of annular ribs 234, 236 which are in sealing engagement with outer wall 242 of plunger 240. The annular ribs 234, 236 serve to retain the plunger 240 in a non-actuated position (as shown in Fig. 9) until the application of a force acting in direction 'Q' sufficient to cause the annular rib and the annular rib 225 closest to plunger end wall 221 to deflect and allow the said plunger end wall to travel downwards.

The plunger housing 200 has an annular end wall to which is affixed sealing member 250 which covers and seals the open end of the plunger housing 200. The sealing member may, for example, be formed from aluminium foil, plastic or other suitable material.

In an alternative embodiment (not depicted) the sealing member 250 may be integrally formed as part of the plunger housing 200 and be manufactured with lines of weakness to facilitate breaking of sealing member 250 when plunger 240 is moved sufficiently in the direction 'Q'.

Referring to Fig. 10, an additive 260 is shown by dotted lines. The additive may take away from, for example one or more capsules or tablets, a powder, or a liquid. The additive may comprise, for example, vitamins, diet supplement(s), a herbal product, an alcoholic beverage or spirit, a condiment, a sweetener or a flavouring. The additive may be separately sealed within a packaging material such as aluminium foil. Preferably, the additive occupies a substantial portion of the space

bounded by the plunger housing, the inner wall 230, sealing member 250 and the plunger actuator end wall 221.

The additive 260 is kept separate from the contents of the container (not shown) and separate from the atmosphere by plunger housing, inner wall 230, outer wall 208, annular sealing engagement features 201 and 201a, sealing member 250, plunger actuator, plunger end wall 221, and annular sealing engagement features 225.

Where the additive is contained within separate packaging then one end wall of the separate packaging preferably extends to the annular edge of the outer wall 208 and the separate packaging is affixed and sealed to the end wall 207 similar to as shown by the position of sealing element 250 or sealed to the end wall 207 and the immediately adjacent outer wall 208 so that the material outer edges of the separate packaging are retained on the end walls 207 so that the additive element may be pushed into the contents of the container through the end of the said separate packaging by the movement of the end wall or disc 221 when the plunger 240 is moved to its full extent in direction 'Q'.

The relative location of the end wall 221 the plunger 240 is designed so that the distance travelled in direction 'Q' by the end wall or end wall 221 is sufficient to completely eject the additive 260 from plunger housing 200 when the lower wall 227 of actuator 224 comes in contact with upper wall 231 of plunger housing 200.

After injection of the additive into the container the closure 100 may be removed from the container by unscrewing in the normal manner, thereby providing access to the contents of the container.

Referring to a further embodiment depicted in Fig. 10, the body of the plunger 240 may be designed such that it has an open end. An actuator disc 224 is formed separately as a cover cap or closure. The cover cap or closure may be attached to the body of the plunger by known means such as thread or clip means 241 to cooperating thread or clip means 228 formed on at least one of the outer or inner wall of the plunger. A stop means 229 located on the outer wall of plunger 240 acts to restrain the extent of movement of the plunger in direction 'Q' upon stop means 229 abutting upper wall 231 of plunger housing 200.

In another embodiment (not shown) the cover cap 240 and the plunger actuator cylinder 226 may be formed as a two piece assembly operating similarly to prior art

resealable dispensing closures extensively referred to in the closure manufacturing and beverage marketing industries as a "push-pull cap" or a "sports cap".

After injection of the additive to the container the cover cap 224 may be removed and the contents of the container will thereby be in fluid communication the open end of plunger actuator cylinder 226 and easily accessible by the user.

Figs. 12 to 15 illustrate a further aspect of the present invention. Fig. 12 shows a cross sectional view of a closure and container neck. The closure 100 has a top wall 102 with a depending annular skirt 104 with threads 106 adapted to cooperate with corresponding threads 12 on the container neck. The closure optionally includes an annular tamper-evident band 110. A dispensing means core 208 is manufactured as part of closure 100 extending above top surface 11 of top wall 20 and having a plurality of dispensing cap lifting ramps 209, dispensing cap lowering ramps 201, annular wall 207, retention feature 202, on a spigot post 205 having wall 206 and spigot post support 203.

Fig. 13 shows a cross section through the centre of a closure 100 with a conical dispensing cap 300 and a tamper-evident cover 400. The conical dispensing cap 300 is provided with a sealing feature 301. A plurality of recesses 304 on the outer surface of the cap 300 provides a knurled finish to provide gripping means when turning the dispensing cap between closed and open positions. A sealing feature 302 is in sealing contact with a complementary annular wall 207 during the opening and closing movement of the dispensing cap so as to provide a seal to prevent leakage of container contents from orifice 204 along wall 207. The sealing feature 302 is restrained by retention feature 202.

A lifting ramp engagement feature (not shown) engages with the lifting ramp 209 and upon rotation of the dispensing cap in an opening direction lifts the dispensing cap 300 to an open position and annular closing ramp engagement feature 303 which in cooperation with closing ramp 201 upon closing rotation causes the dispensing cap to be moved in the closing direction 'C.

The annular orifice 305 is of a diameter 'K' which is smaller than the outside diameter of spigot post 205 such that upon rotation in the direction of closing sealing feature 301 sealingly engages wall 206 thereby providing a positive closure of the container contents from the atmosphere.

Annular base 306 may have on its outer wall 307 shaped areas (not shown) which cooperatively engage with corresponding features (not shown) on inner wall 405 of cover 400 such that the rotation of the said cover will cause the said annular base to rotate.

The tamper-evident cover 400 has a circular top wall 403. Depending therefrom is annular skirt 404 which has an engagement feature 401 which may be an annular ring or consist of more than 1 individual feature. The feature or features engage the upper surface of annular base 306 of dispensing cap 300 thereby locating the cover on the annular base.

Inner wall 405 may have shaped areas (not shown) which cooperate with corresponding features (not shown) on outer wall 307 of dispensing cap 300 to provide locking engagement of cover 400 with dispensing cap 300. In an alternative arrangement shown in Fig. 15 cover 400 may also be located or in locked engagement with dispensing cap 300 by means of one or more of one or both cooperating projections and cooperating recesses on annular base 306 and lower wall 408 . The projections and recesses are numbered 308 and 309 on annular base 306, and 409 and 410 on lower wall 408.

More than one frangible bridge 402 which have depending from them an annular or other tamper-evidence band or means (not shown) which engage with corresponding features such as the types shown at 13 and 14 on top wall 20.

As an alternative to shaping inner wall 405 the cover 400 may also be designed to lockingly engage with the dispensing cap 300 after operation of the tamper-evidence feature there may be depending from top wall 403 more than one locating engagement fin 407 (dotted line and shaded) which engage with recesses 304. Said engagement locating fins may be formed on the inner wall of a cylindrical shape 406 (dotted line) depending from the top wall 403.

Fig. 14 illustrates a plan view of closure 100, including top wall surface 11 lowering ramp 201, spigot post support 203, orifice 204, spigot post 205, and lifting ramp 209.

Fig. 15 illustrates a cross sectional view of cover 400 engagement means 409, 410 engaging with dispensing cap 300 engagement means 308, 309 after tamper-evident means (including known means not shown) has been separated from lower

extremity of wall 404 for example at frangible bridges 402. The engagement or locking engagement means are intended to allow the dispensing cap 300 to be turned from the closed to the open position and open to closed position by gripping and turning the cover and at the first said turning to open to cause by axial movement of the cover 400 whilst tamper-evident means is restrained in engagement with projections or recesses such as 13 and 14 (Fig. 13) on the upper wall 102 (in Fig.12) of and or lifting movement as the dispensing cap engages lifting ramps (209 in Fig. 12) to thereby sever the frangible bridges 402.

Fig. 15 also shows an additional or alternate means of engagement 412 to engage or locate or lock cover 400 and dispensing cap 300 the concept of having the diameter of top wall 403 extend beyond depending wall 404 such that the diameter of top wall 403 may be increased to provide a more secure base on which to stand the package when it is desired to orient the package to drain the container contents by gravity towards the dispensing orifice.

Fig. 16 shows a partial cross section of an alternative dispensing closure which is simplified in that it has less parts and is thereby less costly to manufacture.

Closure 100 incorporates a dispensing means 20 having annular dispensing orifice 22. The annular dispensing orifice 22 is sealed by cooperation with annular sealing device 42 on tamper-evident sealing cover 40.

The tamper-evident sealing cover 40 may be in any shape such as a shape closely following the shape of dispensing portion 20 and or may attach to the closure at points other than that shown by the location of the tamper-evident band 110. For example the tamper-evident band 110 may be located on the dispensing portion 20.

The frangible section 114 which attaches the tamper-evident band 110 to the wall of the tamper-evident sealing cover id severed upon removal rotation of the tamper-evident sealing cover. The tamper-evident band 110 has engagement means to restrict removal rotation and promote fracture of the frangible bridges.

Tamper-evident sealing cover 40 may be re-attached to the closure body after initial opening by means of annular projection 47 which in cooperation with annular engagement ridge 123 locates and holds the tamper-evident sealing cover 40.

Closure 100 may be produced by a mould assembly of the type disclosed in Fig. 16 by modifying the shape of that portion of the closure above top wall annular disc 102 to form the shape the hollow dispensing portion 120.

It is desirable to be able to have a dispensing orifice 22 of smaller or larger diameter according to the viscosity and contained particle size of the contents to be dispensed. Fig. 18 illustrates an orifice device 630 which lockingly engages with dispensing portion 20. The orifice device may have an annular orifice of any desired diameter as illustrated by reference numerals 31, 32 and 33. The orifice device cooperates with annular sealing device 542 to seal the container. Advantageously, use of the orifice device 630 permits the production of only one size closure to satisfy various dispensing requirements. This confers benefits such enabling making one larger cavitation closure mould to accommodate all orifice sizes with corresponding cost efficiencies.

Advantageously, if the orifice device 630 is attached after filling then stock holding of closures for customers requiring dispensing closures with various size dispensing orifices is thereby reduced because the customer holds only one closure size but various sizes of the much smaller orifice variation devices.

In an alternative embodiment, depicted in Fig. 17 the closure does not open and close by means of rotation. In this embodiment, the closure is opened and closed by removal and/or replacement of the tamper-evident sealing cover 540. The sealing cover 540 has an annular sealing device 542 which engages the annular orifice 22 in the dispensing portion 20 of the closure 100. A tamper-evident ring 543 is connected by frangible bridges 545 to the cover wall 546.

The manufacture of the closure illustrated in Figs. 12 to 15 will now be described with reference to Fig. 16. Fig. 16 shows a cross-section of the mould apparatus used to make dispensing closure 100. The mould apparatus features an annular stripper ring 1C which is affixed to plate 1 and which forms the lower surface of wall 30, frangible ribs 116 and part of tamper band 110. The apparatus also features an outer core 2C which is affixed to plate 2 and which forms part of the external wall and the lower surfaces of tamper band 110, the outer wall of tamper band engagement means 122. The apparatus further includes an annular threaded core

3C which is affixed to plate 3 (not shown) annular core 4C which is affixed to plate 4 (not shown) annular core or stripper sleeve 5C which is affixed to plate 5 (not shown).

Annular core 6C is affixed to plate 6 (not shown). The annular core 6 has within it an annular void 8 and hollow tube 7 which is used to conduct cooling water to the uppermost region of the annular core 6 and at least above upper wall 102 of closure 100. The portion of annular core 6 above upper wall 11 of closure 100 forming the inner walls and features including the inner walls being shaped to follow the outer walls and features forming dispensing core means 208 for example the inner wall surface of lifting ramps 209 may be parallel to the upper or outer surface which engages with corresponding lifting ramp engagement means 310 formed on the inside of dispensing cap 300.

The mould apparatus operates as follows.

Molten plastic is injected under pressure through orifice 502 which is in fluid communication with void V2 which is formed in the mould closed position as shown by cooperation between mould portions cavity insert 9C and annular cores 1C, 2C, 3C, 4C, 5C and 6C. The void V2 is thus formed in the desired shape to produce dispensing closure 100.

After plastic is injected into the void V2 and solidification of the plastic has occurred by heat transfer through cavity insert 9C to cooling water circulating channel 9W and through annular core 6C to cooling water circulation channel 8W which may be extended further towards annular retention feature 202 by using a smaller diameter hollow tube 7 and a reduced diameter portion of water circulation channel 8W and if necessary by adding additional cooling means in the form of one or more cooling water circulation channels through annular outer core 2C (not shown).

By relative movement between plate 6 and plates 1, 2, 3, 4, 5 and 9 such that plate 6 moves in direction "C" to withdraw annular core 6 sufficiently to create a void inside dispensing core means 208 at least adjacent to annular retention feature 202 thereby providing a void into which said annular retention feature 202 can deflect upon opening of the mould.

The mould then opens at part line 9A as plate 9 is moved in direction "O".

Plates 1, 3, 5 and 6 then move in unison in direction "O" and plates 2 and 4 do not move or at least do not move relative to plates 1, 3, 5 and 6 and the relative

movement between the annular cores connected to the plates creates void spaces into which seal 40 and portion of tamper-evident band 110 and tamper-evident engagement means 122 can deflect. The relative movement in direction "C" of annular core 4C closes void V1 and opens a similar void adjacent to seal 40 and annular outer core 2C moving a similar distance relative to core 1C opens a similar void adjacent to tamper band 110 and tamper band engagement means 122.

Plate 3 then ceases to move and at least plates 1 and 5 continue moving in direction "O" causing relative movement between plate 3 and plates 1 and 5 thus causing threaded core 3C to disengage from the closure 100. The closure 100 is now free of cores 2C, 3C, 4C and 6C and is held by stripper ring 1C and annular core or stripper sleeve 5C remains in contact with the lower surface 21 of top wall circular disc 20.

Plate 1 then ceases to move and plate 5 continues movement in direction "O" causing core 5 to eject the moulded closure from stripper ring 1C.

Plate 5 then ceases to move and the closure is ejected from the mould.

The mould then closes ready for the next injection cycle.

Further improvements in mould design will now be discussed.

The distance "I" is the total space available to contain the annular cores 3C, 4C, 5C, 6C. It is highly desirable in large multi-cavity moulds operating on fast cycle time to have distance "I" as large as possible at least for the following reasons.

It is desirable to have core 6C as large as possible in diameter so that hollow tube 7 and water channel void 8W can be of sufficient diameter to accommodate the flow of a large volume of cooling water thus enabling the moulded part to solidify and be ejected earlier thus enabling the mould to produce more parts in a given time.

It is also desirable to have the wall thickness of annular cores 3C, 4C and 5C and distance "H" and any interspacing bushes (not shown) of dimension as large as can be accommodated to ensure that the construction of the mould is robust and can last for many millions of cycles.

Preferably, distance "F" (the length of tamper band engagement means 122) and distance "G" the distance from the end of tamper band engagement means 122 to the point at which the outer wall of annular core 3C becomes parallel to the axis of annular cores and by reducing distances "F" and "G" the point at which the outer wall

of annular core 3C becomes parallel to the axis of annular cores occurs such that distance "I" is thereby increased.

Angle "E" is also fundamental in determining distance "I". By restricting angle "E" to less than 50° and preferably 45° or less than the point at which the outer wall of annular core 3C becomes parallel to the axis of annular cores is further from the said axis thereby increasing the distance "I".

With reference to Figs. 19 to 23, a further aspect of the present invention will now be described. The drawings are taken from US Patent No. 5,755,347 and illustrate a closure 32 with a tamper band 35. The band is moulded in an extended position as shown in Fig. 21 and thereafter to facilitate application of the closure to the container, the engagement portion 40 is folded into the position shown in Fig. 19.

Referring to Fig. 20, the engagement portion 40 has segments 43 separated by slots S which serve to reduce the hoop strength of the free edge of the engagement portion 40, thereby enabling it to pass more easily over the tamper band on the neck of the container. However, it is necessary to retain sufficient hoop strength to keep the engagement portion 40 in an engagement position and of necessity there is interference between engagement portion 40 and the container tamper bead 37.

With reference to Fig. 23, upon rotation to remove the closure, the free end of the tamper band 40 comes into contact with the underside of the container tamper bead 37 and the axial force applied is transmitted through the engagement portion 40 to the body of the tamper band 35. The force may be expressed as operating initially on a vector approximately through the line F. However, part of the force will be directed by the geometry and relative positions of the respective features 41, 42, 43, in the direction K which will cause the band 35 to deform outwardly and thereby move hinge point 41 outwards. This serves to increase the angle of the engagement portion 40 and cause an increase in the force acting in the direction K and the decrease acting in the direction L.

Ultimately, engagement portion 40 may be deformed so as to invert without severing the tamper band from the closure, thereby defeating the intended tamper-evidence feature of the closure 40.

The abovementioned problem may be minimised by making the band 35 of sufficient thickness to resist deformation. However, such thickening will make it

more difficult to stretch the band over the container tamper bead thereby making the closure harder to apply to the container.

Fig. 24 is taken from US Patent No. 6,640,988, the contents of which are hereby incorporated into this specification by way of cross-reference. With reference to Fig. 24, there is disclosed a closure with a tamper band where the engagement portion 40 consists of a number of separate elements hinged from a lower end or hinge point 41. This arrangement affords many advantages over the prior art such as U.S. Patent No. 5,755,347 in that there is no hoop strength in the engagement portion of the tamper band to be overcome in the application of the closure.

However, there is still the problem of the force vectors operating through engagement portions 40 to move hinge point 41 outwardly and cause the engagement portions 42 invert before breaking the frangible bridges 38, thereby defeating the achievement of tamper-evidence.

The following aspect of the present invention may be manufactured using the mould equipment and method as disclosed in U.S. Patent No. 6,551,093, which is hereby incorporated into the specification by way of cross reference. This aspect of the invention provides a closure with a tamper band having more than one engagement portion 40 with a removal force vector angle closer to direction L so as to reduce the propensity of the tamper band 35 to deform outwardly when removal force is applied to the engagement portions 40. This is achieved by locating the hinge point 41 closure to the axis of the closure. Such relocation is brought about by thickening the tamper band 35 at the hinge point 41. In doing so, the force vector angle is reduced, causing more of the removal force to operate in the direction L and less to operate in direction K. Furthermore, thickening the band facilitates resistance to outward deformation which assists in maintaining the position of hinge point 41, thus maintaining maximum force vector in direction L. The thinner portion of the band above hinge point 41 leaves an area into which the free of engagement portion 40 can flex during application as the engagement portion 40 passes over the container tamper bead 37.

Referring to the comparative drawings Figs. 25 and 26 (prior art), the force vector operating upon removal at hinge point 41 to stretch the band 35 is reduced by about 60% (reduced from about 15 degrees to about 5 degrees); and the increase in

hoop strength by thickening the lower portion of the band 35 will further contribute to resisting stretching of the band upon removal. Both of these changes act together to ensure that the hinge point 41 is more resistant to outward movement under the stress of removal, thus ensuring that the engagement portions 40 are held in place to effect separation of the tamper band from the closure.

A further aspect of the present invention will now be described with reference to Figs. 27 to 33 and relates to a tamper-evident closure and corresponding container neck, and to a closure mould assembly.

Referring to Fig. 31, the neck 100 has an outer wall 105, an inner wall 130 and a top wall 135 joining the outer and inner walls. The outer wall 105 is provided with one or more external threads 110 adapted to cooperate with a corresponding internal thread or threads on the closure. In the case of multi-start threads the thread profile may be of narrower profile on both neck and closure to allow for the axial or push-on application of the closure to the container. The threads may be continuous or segmented as required. In the case of containers for carbonated beverages, threads 110 cooperate with the closure threads to retain the closure on the neck whilst the pressurised gas vents. To accomplish this the threads of one or more of the closure or the container neck may be slotted or segmented to facilitate release of the gas.

The neck includes a tamper bead 115 with a face 116 to cooperatively engage with a tamper-evident ring or tamper-evidence engagement means on the closure. The tamper bead may be advantageously segmented with equal spaced gaps 'Y' to reduce the quantity of material required.

One or more ramped angled projections 120 are located below the tamper bead and shaped such that ramped surfaces 124 allow corresponding ramped surfaces on the closure to pass over during application of the closure to the container neck. However, upon rotation to remove the closure, engagement surfaces 122 engage with corresponding engagement surfaces on the closure thereby promoting early breakage of the frangible bridges and separation of the tamper ring from the skirt of the closure as described below.

Referring to Fig. 29a, the closure 10 consists of a disc 20 with an upper wall and a lower wall 13. One or more sealing means such as annular sealing means 40, 41 depend from the inner wall 13. The sealing means 40, 41 act to sealingly engage in

such manner as to create a seal between closure and container that will have at least one sealing means operating until the tamper-evident ring is substantially separated from the closure skirt thus giving clear evidence of the seal being breached.

One or more retention means 42 may be provided to retain, for example, a cup or receptacle or disc or device (not shown) either within or depending from the closure. The retention means 42 may take the form of one or more clips, projections, recesses, rings, annular flange, interrupted or segmented annular flange annular groove or recess interrupted or segmented annular groove or recess depending from the lower wall of the closure. An object, such as a cup, may be engaged with the retaining means so as to be held in position whilst the closure is sealingly engaged to a container but may be removed to access the contents (such as food or beverage additives) contained in the cup.

The skirt 30 of the closure has an inner wall with a raised thread which cooperates with the external thread on the neck of the container.

A tamper-evidence ring 55 depends from a lower wall of the skirt by means of frangible bridges 50.

The neck of the container includes an engagement means with the tamper bead on the neck of the container such engagement means 58 consisting of but not limited to any one or more of and in any combination thereof which combination may omit one or more of

a ramped projection which is shaped to more easily pass over the tamper bead on the neck of the container on application of the closure but also shaped that upon removal of the closure from the container the projections engage with corresponding surface on the container neck promoting early breakage of the frangible bridges and separation of the tamper ring from the skirt of the closure.

The flap 58, which may be folded after moulding, may be thicker at one end than the other and may have stiffening ridges thereon. The flap may be shaped to facilitate folding and may be advantageously moulded in a position where end 59 is closer to the axis or centre of the closure to ensure that when folded into the closure the flap will tend to be in a position to engage with both the wall 105 and the engagement faces 116 and 118.

With reference to Fig. 29, a flap may be moulded in a position to allow one or more projections 73 to be created on the wall of the flap 58 such that when folded into position inside the closure (shown with dotted line)

the ramped surface 72 shaped to more easily pass over the tamper bead on the neck of the container upon application of the closure(not shown)and

the ramped projection surface 72 shaped to easily pass over corresponding (in Fig. 31) ramped surfaces 124 on projections 120 on the neck of the container below the tamper bead 115 upon application of the closure(not shown) and

whereupon the closure is rotated in the direction to remove the closure from the neck of the container then the surfaces 70 and 59 of the said projections 73 respectively engages with corresponding engagement surfaces 122 and 116 on the neck of the container thereby restraining movement of the tamper ring and promoting early breakage of the frangible bridges and separation of the tamper ring from the skirt of the closure and the projection shape 74 in partial view 2 of Fig. 29 having a dimension 'X' being a dimension larger than the gaps dimension 'Y' shown in Fig. 32 in a segmented tamper bead 115 of a corresponding container neck

a projection (not shown) which may be shaped so as to engage with the tamper bead on the container neck but also shaped to assist removal from the mould and

any combination of the foregoing.

The mould assembly comprising first and second mould portions which cooperate to define when in a closed position, a closure cavity;

the first mould portion containing the means of injection of polyolefin material and defining or partially defining

the external features of the top disc and skirt of the closure and

one or more raised features on the exterior of closure which may cooperate with closure application means or closure ejection means.

The second mould portion having one or more of and or means of cooperation between and in any combination thereof

a threaded core shaped to define any one or more of and in any combination thereof which combination may omit one or more of

threads on the inner wall of the closure skirt such threads cooperating with the threads on the neck of the container

annular sealing means depending from the lower wall of the closure disc and/or the inner wall of the closure skirt or any combination thereof and such sealing means to sealingly engage with any one or more of or in any combination of

the inside wall of the container neck

the top wall of the container neck

the outer wall of the container neck

annular or interrupted annular retention means depending from the lower wall of the closure disc such that an object (such as a cup or receptacle or disc or device) may be engaged with the retaining means such that the object is held in position whilst the closure is in use or alternatively the object but may be removed to access the contents (such as food or beverage additives) of the receptacle. The retention means may, for example, take the form of one or more of clips, projections, recesses, annular flange, interrupted annular flange annular groove or recess interrupted annular groove or recess

an annular support ring shaped and positioned to form one or more of or portion of and in any combination thereof which combination may omit one or more of

part of the outside wall of the skirt

a projection on the outside wall of the skirt

a shoulder defining the lower extremity of the skirt

at least a portion of the tamper-evident ring

one or more frangible bridges connecting the skirt to the tamper-evident ring

an outer core which cooperates with the threaded core and the support ring to define at least portion of an annular tamper-evident ring and by cooperative movement relative to the support ring and the threaded core creates a space into which the tamper-evident ring may deflect to assist ejection of the closure.

one or more inner cores which may be shaped to define at least portion of the one or more of and annular sealing means and or annular or interrupted annular retention means and which by collective cooperation and relative movement between the said inner cores and the threaded core assists ejection of the closure from the mould.

the inner cores and the threaded core cooperating and by relative forward or opening movement in relation to the support ring cause the closure whilst still remaining on the said inner cores and threaded core to move away from the support ring.

the inner cores and the threaded core cooperating and by relative forward or opening movement of one or more of the inner cores relative to the threaded core eject the closure off the threaded core.

Alternatively the support ring may move forward relative to the threaded core thereby withdrawing the threaded core from the closure and further forward movement by the inner core or cores removes the closure from contact with the support ring and ejects the closure from the mould

if the closure is still retained on the inner cores by portion of the closure such as the said retention means then by cooperative forward or opening movement of the innermost core relative to the other inner core the closure may be ejected off the inner core.

The present invention includes a cup or receptacle (not shown) shaped with features which cooperate with the said retention means within the closure such means of cooperation being for example but not limited to one or more of clips, projections, recesses, annular flange, interrupted annular flange annular groove or recess interrupted annular groove or recess.

In a further non-limiting aspect of the invention suitable for use with or without cup retention means we show in Fig. 28:

a tamper-evident closure 10 (shown partially) with a top wall 20 and

an annular sealing device 40 sealingly engaging the inside wall 65 of the container neck 60 and

another annular sealing device 41 which may also but not necessarily be used to sealingly engage with either or both the upper wall 63 and the outer wall 64 of the container neck 60 (shown not fully sealingly engaged).

The design of the closure being such that when the closure is fully applied

the distance 'A' being the distance over which an interference fit and seal continues to occur between the annular sealing device 40 and the inner wall 65 of the

container neck 60 during removal of the closure from the fully applied position (not shown) on the container neck and

further described as being the distance between

line A1 being the line touching the top wall 63 of the container neck and the line A2 being the line touching point of sealing engagement between annular sealing device 40 and the inner wall 65 of the container neck 60 measured at the point when the closure is fully applied(not shown) to the container neck

shall be always sufficiently larger than the distance 'B' being the distance between the engagement surface 61 of the tamper bead 62 and the engagement surface 59 of the tamper ring engagement means 58 when the closure is fully applied to the container) plus

a distance 'C' (not shown) equalling the amount of compression that occurs in the tamper ring engagement means during the process of removal plus

a distance 'D' (not shown) equalling the amount of stretch that occurs under stress during closure removal in the frangible bridges 50 connecting the tamper-evidence annular ring 55 to the closure skirt 30 plus

a distance 'E' (not shown) being the distance equal to the tolerance allowed in the measurement specifications of the container neck 60 and the closure 10 plus as may be required a distance for margin of safety for a particular closure and neck combination.

By observing this formula in designing a closure then the closure will be in sealing engagement with the container neck until after tamper-evidence is displayed thereby ensuring that no contamination of contents can occur without tamper-evidence.

The foregoing inventions may be adapted according to the following procedure for closures using sealing methods other than that described in the foregoing example of closures with a bore seal on the inside neck surface of the container.

Where closures seal by other than a bore-seal the distance 'G' over which the seal is effectively in contact with the neck of the container expressed as the number of removal rotations or portion of a rotation of the closure during removal is substantially less than distance 'A' referred to in the bore-seal example in Fig. 28.

To compensate for this the tamper-evidence feature must be caused to operate promptly upon removal rotation of the closure.

Referring to Fig. 29, the present invention is designed to restrain the movement of the tamper-evident ring 55 on the closure by including cooperating engagement means 58 on the tamper-evident ring and engagement means 115 on the container neck (shown in Fig. 31) such that upon removal rotation the said cooperating engagement means engage and further removal rotation fractures the frangible bridges 50 separating the tamper-evidence ring 55 from the closure skirt 30. The present invention including container necks is described in the following non-limiting examples.

Referring to Fig. 29, Partial View 1, shows the lower edge 59 of tamper-evident engagement means 58 with protrusions 73 having engagement faces 70 and ramped surfaces 72 . The protrusions are spaced around the whole of the lower portion (as moulded) of the tamper-evident engagement means 58 with the protrusions 73 protruding in the direction 'B' such that when the tamper-evident engagement means 58 is folded into the closure (shown with dotted line then the protrusions are oriented to upon rotation of the closure in the direction of removal engage with (shown in FIG. 4.) the corresponding neck engagement means 115 and 120 on the container neck . The neck engagement means 115 have engagement faces 116 to restrain axial movement and engagement faces 122 to restrain rotational movement of the tamper-evidence ring 55 and upon further removal rotation of the closure sever the frangible bridges 50 and

Partial View 2 shows an alternative configuration of protrusions 73 and 74 which are designed to cooperate with as shown in FIG. 5 and FIG. 4 or a combination of FIG. 4 and FIG. 5 such that the distance 'X' on protrusion 74 is greater than the distance 'Y' shown in FIG. 5 thus preventing protrusion 74 from passing through the gap 'Y' in the tamper bead 115 and retaining the tamper band 55 on the neck of the container.

Partial View 3. shows a corresponding view of Partial View 1 as seen from location 'B'.

Referring to Fig. 30a, Partial View 4 is a view from location 'B' showing protrusions 76 extending from the lower edge 59 of tamper-evidence engagement

means 58 to form a series of tooth like engagement devices 76 having engagement faces 70 and ramped surfaces 72 and first engagement points 75 which are designed upon removal rotation to progressively engage (shown in Fig. 32) with corresponding engagement faces 116 and 118.

Partial View 5 is a perspective view from the direction 'C' showing the tamper-evident engagement means 58 folded inside the closure . As can bee seen the engagement faces 70 will be able to engage both of the corresponding neck engagement means 116 and 118 (shown in Fig. 32) and the face of the tamper-evidence engagement means 58 which passes over the tamper bead 115 upon application has no projections thereon and will by deflecting outwardly towards the outside of the closure. In the event that the surfaces 72 abut the corresponding opposite surface of engagement face 116 on the container tamper bead 115 during the passing of the tamper-evidence engagement means 58 over the tamper bead 115 then the ramped shapes of surface 72 will assist.

The corresponding formula for non bore-seal or shallow bore-seal closures is

The distance 'G' which is the distance represented by that fraction of a turn in the direction of removal which must always be less than the distance 'H' (not shown) being the corresponding rotational measurement to distance 'B' (in the bore-seal formula) this dimension as may be required also takes into account during the closure design stage of the compression of the sealing means against the upper surface 135 of the container neck plus the distance 'I' (not shown) which is the fraction of a rotation necessary to present engagement faces 70 and engagement points 75 on the tamper ring against corresponding engagement faces 116 and 118 on the container neck plus the distance 'J' (not shown) being the corresponding rotational measurement to distance 'C' (in the bore-seal formula) . This number can be minimised through the addition of stiffening ribs or ridges and/or use of more rigid plastics

plus

the distance 'K' (not shown) being the corresponding rotational measurement to distance 'D' (in the bore-seal formula) plus

the distance 'L' (not shown) being the corresponding rotational measurement to distance 'E' (in the bore-seal formula).

Now referring to Fig. 30a we disclose

that the retention device 42 may usefully be located further away from the skirt of the closure especially in closures of larger diameter.

the retention device 42 is also not limited to the shape shown but may be shaped to correspond with the cup or container or device being retained (not shown) which may also be shaped such that one or more of or combination of cooperating clips, projections, recesses, annular flange, segmented or interrupted annular flange, annular groove or recess, interrupted annular recess and said cup and retention means 42 may be advantageously designed for example with a chamfered flange on the cup so that the cup is easily fitted into the retaining means 42 and this assembly may usefully be combined in a closure with the sealing means 41 or its mirror image 43 shown with dotted line.

Referring to Fig. 30a we hereby disclose a design for sealing means 41 and or 43 which may advantageously be constructed with the cross sectional dimension decreasing progressively from the point of joining with the lower wall 13 of the closure disc 20 and the said point of joining having a radius (not shown) such that the over all design of sealing means 41 and or 43 facilitates easy removal from a mould assembly (not shown)

the features 41 42 and 43 may also be shaped advantageously according to known means.

Referring to Figs. 32 and 33, which illustrate a plan view of two embodiments of container necks which correspond with the closures disclosed herein. The necks can be divided into quadrants Q_1, Q_2, Q_3 and Q_4 as shown.

In Fig. 32 all four quadrants are similar, whilst in Fig. 33 Q_2 is the mirror of Q_1 and the half Q_3 and Q_4 is the mirror image of the other half Q_1, Q_2. The interruptions or gaps 'Y' in the tamper bead 115 may be shaped differently according to the means of manufacture or desire to minimise the amount of material used. The relationship of gaps 'Y' to segments 'Z' may usefully be varied to save material for example by making the dimension ratio 3Y to 2Z resulting in a material saving is in the order of 60% of the material used in a solid tamper bead and such container necks and tamper beads can be designed so as to operate with other closures.

The various aspects of the present invention can be applied to dispensing closures for particular dry goods, such as spices. For example, closures of the type

disclosed in US Patent No. 6,341,720 are 5,799,838 may be adapted as illustrated in accompanying Figs. 33 to 35. With reference to Figs. 34 to 36, the closure 10 has an annular retention features 123 which, in cooperation with annular projection 47 on over cap 40 serves to retain the over cap when replaced onto the closure after the initial fracturing of the frangible bridges of the tamper-evident ring 43. An opening 70 is provided for spoon or bulk dispensing, whilst an adjacent opening 71 comprising a plurality of apertures is provided for a shaker-type dispenser.

The tamper-evident over cap 47 has discrete sealing means 85 and 86 respectively sealing the closure openings 70 and 71. The sealing means operate by means of interference fit between outer walls 84 and inner walls 49 of the openings 70 and 71. One or more hinge lines 80 which may be spaced apart, allow one or more over cap portions (for example over cap portion 88) to be lifted upwards to allow dispensing of contents of the container through the orifices. Preferably, one of the hinge lines is located such that more than 50% of the circumference of the over cap remains affixed to the closure by cooperation between the annular retention feature 123 and annular projection 47.

Referring to Fig. 37, a partial section of the tamper-evident closure and receptacle or cup is depicted. The closure 10 has sealing means 40 to sealingly engage the inside wall 65 of a container neck and sealing means 44 to sealingly engage the outside wall 64 of the container neck 60. A tamper band 55 is attached to skirt 30 by means of frangible bridges 50 and more than one tamper band engagement portion 58 is separate from each other, thus facilitating less resistance when passing over the container tamper bead 61 upon application to the container.

The cylindrical receptacle 150 may be integrally formed in the closure, or manufactured as a separate component and secured to the inside of the upper wall of the closure. The receptacle may be of any desired length but advantageously its length extends from the top wall 20 of the closure to between the lines marked "G" and "H", such that the end of the receptacle does not project from the closure whilst the tamper band 55 is on the closure, thus facilitating ease of sorting and orienting and applying the closure to the container. When the closure is removed from the container, the end of the receptacle will project from the closure thus facilitating removal of any sealing means applied to the open end of the receptacle. The

receptacle sealing means is necessary in order to separate the contents of the receptacle from the contents of the container. The receptacle has an inside wall 151 and an outside wall 152, the walls being thicker at the point at which the walls join the top wall 20 of the closure. The receptacle walls are thinner at the open end of the receptacle. Preferably, the tapering in the walls of the receptacle is sufficient to allow easy removal of the mould by the relative movement between one or more mould components and/or relative movement between the mould components and the closure.

With reference to Figs. 38 and 38a, the mould assembly disclosed by Taha in US Patent No. 6,551,093, which is hereby incorporated into the specification by way of cross-reference, has been modified to create the receptacle walls 150 and 151. The annular receptacle may be of a smaller diameter and located closer to the mould portion 220. On larger diameter closures the width of the mould portion 210 can be increased, thus facilitating creation of receptacle walls of greater length than that shown.

Advantageously, the various embodiments of the tamper-evident closure according to the present invention may be adapted or combined with one or more of the openings to dispense the contents of a container, or the threads and tamper-evident bead on the outside skirt so that a plug seal type over cap can be affixed to the basic closure in order to seal the container initially and provide clearly visible evidence that the over cap has been opened. Additionally this provides means to reseal the container. This is useful, especially in instances where the container has a wide dimensional tolerance, since the basic closure can be snapped into a sealing position and not able to be removed without first removing the tamper-evident band. The over cap can be designed to seal more effectively in multiple removal/resealing operations.

The present invention includes any one or more of the aspects disclosed herein incorporated with the mould assembly and closures disclosed in US Patent Nos. 4,598,833, 6,551,093, 6,626,310 and 6,640,988 and Australian Patent No. 550878 and Australian Patent Application No. 79927/98 the disclosures of which are hereby incorporated into this specification by way of cross-reference.

The various aspects of the present invention described above may be combined with any one or more of the following:

(i) Various child-resistant features, one of which may be of the type whereby it is necessary to exert downward force either on the top of the closure or on the top of an over-cap which fits over the top of the closure, such that the downward force overcomes resistance thereby allowing engagement means between the over-cap and the closure to enable removal rotation of the closure to operate the tamper-evident feature and remove the closure from the neck of the container.

(ii) child-resistant tamper-evident closures, including a "squeeze dropper" type dispensing closure.

(iii) Dispensing closures for liquids, such as oils.

(iv) Dispensing closures for particulate matters, such as granular powders and the like.

(v) The moulding of the closure from more than one type of material. For example, it would assist recycling if the closure tamper-evident band was moulded in the same material as the container. In another example a different colour or type of material may be used to mould the tamper band promoting visual difference between closure body and tamper band or physical performance of the tamper band.

(vi) Various dispensing means such as, but not limited to, a perforated or partially perforated closure with flip top cover, a flexible membrane with cruciform or other pattern slits or openings to thereby permit the dispensing of container contents or a pump action dispenser or a push/pull valve closing/opening feature.

(vii) A closure applied by axial rather than rotational motion and closures with more than one thread means.

(viii) A closure with a cooperating ratchet or engagement means between the tamper-evident band and features on the neck of the container such that cooperation between the said engagement means or any of them upon removal rotation of the threaded closure tends to promote severing of the frangible ribs connecting the tamper-evident band to the skirt of the closure. Said engagement means having ramped surfaces which cooperate during application of said closure to said container neck to

reduce rotational force on the tamper-evident band during application reducing the possibility of severing the frangible ribs connecting the tamper-evident band to the skirt of the closure.

(ix) Various means of employing an additional foil seal to ensure freshness of the contents of a container and which may include a means to pierce the foil.

(x) Closures made of metal or plastic materials, or a combination of metal and plastic materials as may be useful in hot fill vacuum seal packages.

(xi) Containers made of plastic, metal and glass materials.

Although the various aspects of this invention have been described with reference to specific examples it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.